and those with myelitis. (6) The psychic stage is the largest of those that make up the simple reaction-time, except with the epileptics, where it is exceeded by that of centrifugal conduction.

Mental Association investigated by Experiment. Prof. J. McK. CATTELL and S. BRYANT, D. Sc. Mind, April, 1889.

These experiments touch the question at two points: the time required, and the relative frequency of the different kinds. Three methods were used: one in which a printed word was shown, the word suggested called out, and the time accurately measured with apparatus; another, in which lists of ten words were shown, the word suggested by each called out, and the time for one found from the time for all; and a third, in which a word was pronounced and the subjects wrote down the words successively occurring to them in 20 seconds. None of these measure the bare process of association, and the second and third take in other processes; still it is possible by them to reach relative results of some certainty and to gather interesting statistics. The first method, used by Cattell and Berger, gave average association times of about half a second. The second method was used by the experimenters on themselves with very many words, and, with fewer, on a number of other people, including university graduates, students in a ladies' college and in a German gymnasium. The times found vary from 1.14 to 7.07 secs., the first for Cattell himself with concrete nouns, the second for the youngest boys tested at the gymnasium and with abstract nouns. The third was applied chiefly with London and Dublin school-girls. The oldest and most advanced averaged one association in 4.13 seconds, the youngest one in 9.33. Of the twenty nouns used, the English girls gave the greatest number in 20 seconds for "ship" (4.8), the least for "virtue" (2.3). The different series show that the association time is longer for abstract than for concrete nouns, and that maturity and mental discipline tend to reduce this difference.

Of fresher interest are the statistics of frequency. The first table, based on the associations of 465 persons with 10 concrete and 10 abstract nouns, gives the associations occurring ten times or over. The table averages less than eight associations per word, and yet contains more than half of all given—an evidence of the general uniformity of mental action in different individuals. All the associations with the words "house" and "time" were classified after a scheme like Wundt's, and showed, among other things, that most of the associations of co-existence were visual, like "house" and "garden"; most of those of succession were verbal, like "house" and "house-top." Treating in the same way a mass of over 12,000 observations from 512 persons, school-girls predominating, it appears that concrete nouns owe their associations a little more frequently to connection in sensation than to logical connection; that to go from whole to part, or to specialize, is much commoner than to go from part to whole, or to generalize; also that it is easier to go forward ("house" to "house-top") than backward ("house" to "glass house"), and easier to go to final than to efficient causes. The associations of abstract nouns, except verbal associations, are rarely due to the senses; about two thirds of the cases were correlations and specializations. Classifying again for observers, it appeared that those that write and teach prefer logical and verbal associations; two teachers gave respectively 33 and 26 per cent of verbal associa-

tions against about 1 per cent for their pupils ; the favorite form for the latter was from whole to part. A further table shows the influence of the original word used, "tree," for example, suggesting "leaves" (whole to part), while "courage" suggested its like or its opposite. By no means the least interesting part of the research, and one contributing greatly to the proper conception of the results, is the appendix of subjective observations by the experimenters and several of their subjects.

(1). *Untersuchung über die Latenzdauer der Muskelzuckung in ihrer Abhängigkeit von verschiedenen Variabeln.* Dr. ROBERT TIGERSTEDT. Archiv für Anat. u. Physiol. (Physiol. Abth.), 1885, p. 111.

(2). *Die Scheinbare Latenzperiode der Erregung bei directer Muskelreizung.* Dr. EMERICH NAGY v. REGÉCZY. Pflüger's Arch., Vol. 43, p. 584.

(3). *On the Normal Duration and Significance of the "Latent Period of Excitation" in Muscle-contraction.* G. F. YEO. Jour. of Phys., Vol. IX, p. 396.

Helmholtz in 1850 discovered that a period of time elapses between the moment of stimulating a muscle and the commencement of the ensuing contraction. He found this latent period to be approximately 0.01″, and thought that submaximal shocks, as well as loading, overloading and fatigue, caused this value to vary. He did not attempt to explain the meaning of this lost time, and even thought it possible that contraction might begin immediately on stimulation.

Since 1850 other investigators have variously estimated the latent periods within very wide limits; but after the researches of von Bezold and Bernstein, a duration of 0.01″—0.02″ seems to have been universally accepted as the normal period, coupled generally with the view that this time is consumed by certain molecular changes prerequisite to contraction.

In 1879, however, Gad combated this opinion, and was led by Bernstein's work, which showed the latency of the electric changes of the muscle preceding contraction to be about 0.001″, to regard the latency of the individual muscle elements as of similar amount. He pierced the belly of the muscle with a recording lever, and, upon stimulating the lower end, obtained a curve indicating an initial lengthening of the muscle before contraction began. He considered this as evidence that when the muscle is stimulated, the muscle elements originate a local contraction and stretch their fellows more remote. According to his view, therefore, the latent period is the time required for the contraction to include a number of muscle elements more than sufficient to compensate the initial elongation. Since the whole must be greater than any of its parts, he maintains that the latency of the individual elements must be less than that of the whole muscle.

(1). In *du Bois-Reymond's Archiv* for 1885, Robert Tigerstedt gave the results of his research upon the latent period. As had been conceded before him, he found that temperature was an important condition, and concluded that the latency from 12°—16°.9 C. is 0.006″; from 17°—18°.9, 0.005″; and from 20°—29° C., 0.004.″ Bernstein had discovered that the impulse from nerve to muscle was delayed in the nerve endings 0.0032″. Tigerstedt, who adopts 0.002″ instead of 0.0032″, notes that in direct maximal stimulation of an uncurarized muscle, in consequence of this delay, there are